Claims

[c1] 1. A catalyst system for use in reducing emissions from an exhaust gas stream containing hydrocarbons, CO and NOx comprising:
a first catalyst for optimizing the storage of NOx emissions under lean air/fuel ratios, comprising a first zone and a second zone;
said first zone comprising a) a catalyst mixture PM-Rh, where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, and b) a metal oxide selected from the group consisting of oxides of aluminum, alkali metals, alkaline-earth metals, and combinations thereof, wherein said first zone is devoid of cerium;
said second zone comprising a) a catalyst mixture PM-Rh, where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, and b) a metal oxide selected from the group consisting of alkali metals, alkaline earth metals, rare earth metals and combinations thereof; and
a second catalyst for optimizing the reduction of hydrocarbon, NOx and CO emissions under stoichiometric air/fuel ratios comprising: a) a catalyst mixture PM-Rh, where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, b) a metal oxide selected from the group consisting of oxides of aluminum, alkali metals, alkaline earth metals and combinations thereof, and c) a metal oxide selected from the group consisting of oxides of zirconium, cerium and combinations thereof.

[c2] 2. The catalyst system of claim 1, wherein said second zone of said first catalyst further comprises zirconium oxide.

[c3] 3. The catalyst system of claim 1, wherein said second catalyst further comprises hydrogen sulfide emission suppressants.

[c4] 4. The catalyst system of claim 1, wherein said second catalyst further comprises nickel oxide.

[c5] 5. The catalyst system of claim 1, wherein said Rh in said first catalyst is placed on ZrO_2 particles of 3-5% (wt).

[c6] 6. The catalyst system of claim 1, wherein said catalyst mixtures of said first

and second catalysts are coated on an alumina substrate.

[c7] 7. The catalyst system of claim 6, wherein said alumina substrate in said first zone is stabilized by between 1-8% (wt) La_2O_3.

[c8] 8. The catalyst system of claim 6, wherein said alumina substrate in said second catalyst is stabilized by 2-15% (wt) BaO.

[c9] 9. The catalyst system of claim 1, wherein said first zone of said first catalyst further comprises a metal oxide selected from the group consisting of barium oxide, magnesium oxide, potassium oxide and combinations thereof, wherein the metal oxide comprises 2-15% (wt).

[c10] 10. The catalyst system of claim 1, wherein said second zone of said first catalyst further comprises a metal oxide selected from the group consisting of barium oxide, magnesium oxide and combinations thereof.

[c11] 11. The catalyst system of claim 10, wherein said second zone of said first catalyst comprises BaO and MgO of 10-40% (wt).

[c12] 12. The catalyst system of claim 1, wherein said catalyst mixture PM-Rh in said first zone of said first catalyst comprises Pt and Rh in a ratio of between 5:1 and 25:1.

[c13] 13. The catalyst system of claim 1, wherein said catalyst mixture PM-Rh in said first zone of said first catalyst has a loading of between 60-300 g/ft^3.

[c14] 14. The catalyst system of claim 1, wherein said second zone of said first catalyst comprises Pt and Rh in a ratio of between 1:1 and 10:1.

[c15] 15. The catalyst system of claim 1, wherein said catalyst mixture PM-Rh in said second zone of said first catalyst has a loading of between 10-100 g/ft^3.

[c16] 16. The catalyst system of claim 1, wherein said catalyst mixture PM-Rh in said second catalyst comprises Pt and Rh in a ratio of btween 5:1 and 15:1.

[c17] 17. The catalyst system of claim 1, wherein said catalyst mixture PM-Rh in said second catalyst has a loading of between 10-120 g/ft^3.

[c18] 18. The catalyst system of claim 1, wherein PM-Rh in said second catalyst comprises Pt and Rh placed on Ce and Zr particles of 5-30% (wt) wherein the molar ratio of Ce and Zr is 50:50.

[c19] 19. The catalyst system of claim 1, wherein said first catalyst and said second catalyst are close-coupled, said first catalyst being positioned in a forward position and said second catalyst being positioned in a downstream position.

[c20] 20. The catalyst system of claim 1, wherein an exhaust gas sensor is placed between said first and second catalysts.

[c21] 21. A catalyst system for use in reducing emissions from an exhaust gas stream containing hydrocarbons, CO and NOx comprising:
a first catalyst for optimizing the storage of NOx emissions under lean air/fuel ratios comprising a top layer and a bottom layer;
said top layer comprising a) a catalyst mixture PM-Rh, wherein said PM is a catalyst material selected from the group consisting of Pt and Pd and combinations thereof, and b) a metal oxide selected from the group consisting of oxides of aluminum, alkali metals, alkaline earth metals and combinations thereof, wherein said top layer is devoid of cerium;
said bottom layer comprising a) a catalyst mixture comprising PM-Rh wherein PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, and b) a metal oxide selected from the group consisting of oxides of aluminum, alkali metals, alkaline earth metals and combinations thereof; and
a second catalyst for optimizing the reduction of hydrocarbon, NOx and CO emissions under stoichiometric air/fuel ratios comprising a) a catalyst mixture PM-Rh, where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, and b) a metal oxide selected from the group consisting of oxides of aluminum, alkali metals, alkaline earth metals and combinations thereof, and c) a metal oxide selected from the group consisting of oxides of zirconium, cerium, and combinations thereof.

[c22] 22. The catalyst system of claim 21, wherein said top layer of said first catalyst comprises Pt and Rh in a ratio of between 5:1 and 25:1.

[c23] 23. The catalyst system of claim 21, wherein said catalyst mixture PM-Rh in said top layer of said first catalyst has a loading of between 60-300 g/ft ^{3}.

[c24] 24. The catalyst system of claim 21, wherein said catalyst mixture PM-Rh in said top layer of said first catalyst comprises Pt-Rh stabilized by 2-15 wt% of BaO.

[c25] 25. The catalyst system of claim 21, wherein said Rh in said second bottom layer of said first catalyst is placed on ZrO_2 particles of 3-5% (wt) and BaO and MgO particles of 2-30% (wt).

[c26] 26. The catalyst system of claim 21, wherein said catalyst mixtures of said first and second catalysts are coated on an alumina substrate.

[c27] 27. The catalyst system of claim 26, wherein said alumina substrate in said bottom layer of said first catalyst is stabilized by between 2-8% (wt) La_2O_3.

[c28] 28. The catalyst system of claim 26, wherein said alumina substrate in said bottom layer of said first catalyst is stabilized by composite oxides of cerium-lanthanum.

[c29] 29. The catalyst system of claim 21, wherein said catalyst mixture PM-Rh in said second catalyst comprises Pt and Rh in a ratio of between 5:1 and 15:1 with a total loading of between 10-120 g/ft ^{3}.

[c30] 30. The catalyst system of claim 21, wherein PM-Rh in said second catalyst comprises Pt and Rh placed on Ce and Zr particles of 5-30 wt%, wherein the molar ratio of Ce and Zr is 50:50.

[c31] 31. A catalyst for use with an internal combustion engine to provide emission reductions, comprising:
a first and a second zone;
said first zone comprising a) a catalyst mixture PM-Rh where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, and b) a metal oxide selected from the group consisting of cerium, zirconium and combinations thereof; and
said second zone comprising a) a catalyst mixture PM-Rh, where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof;

and b) a metal selected from the group consisting of oxides of aluminum, alkali metals, alkaline earth metals and combinations thereof, wherein said second zone is devoid of cerium.

[c32] 32. A catalyst for use with an internal combustion engine to provide emission reductions, comprising:
a first, second and third zone, said first zone comprising a) a catalyst mixture PM-Rh where PM is a catalyst mixture selected from the group consisting of Pt, Pd and combinations thereof, and b) a metal oxide selected from the group consisting of cerium, zirconium and combinations thereof;
said second zone comprising a) a catalyst mixture Pm-Rh, where PM is a catalyst material selected from the group consisting of Pt, Pd and combination thereof; and b) a metal selected from the group consisting of oxides of aluminum, alkali metals, alkaline earth metals and combinations thereof, wherein said second zone is devoid of cerium; and
said third zone comprising a) a hydrogen sulfide suppressant, b) a catalyst mixture PM-Rh where PM is a catalyst material selected from the group consisting of Pt, Pd and combinations thereof, and c) a metal oxide selected from the group consisting of cerium, zirconium and combinations thereof.